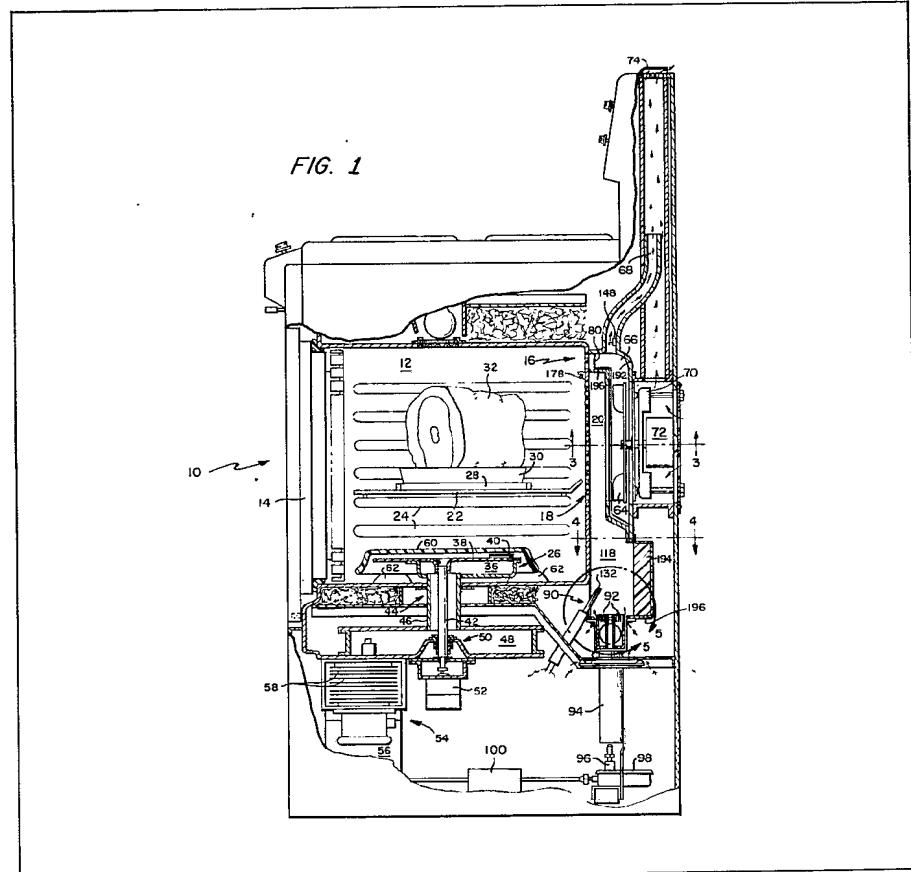


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**(54) Gas burner convection oven**

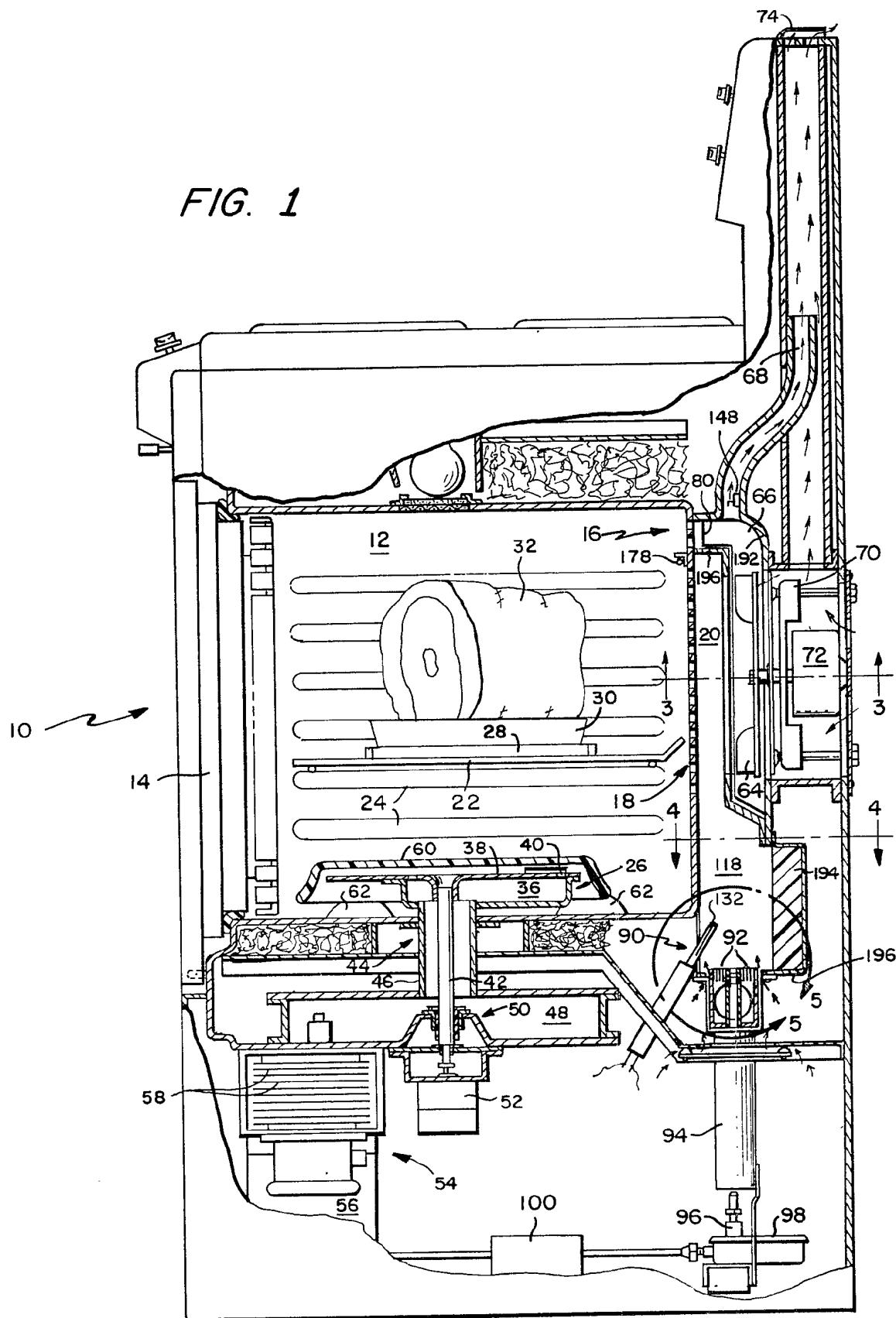
(57) Hot vapour is circulated through the oven enclosure 12 by an external pair of counter-rotating blowers 64 positioned in the rear of the oven. The blowers 64 draw vapour from the enclosure 12, entraining combustion products from a multi-section ribbon burner 92 and blow the combined vapour into the enclosure 12 via a screen 16. The blowers 64 generate a slight negative pressure in the combustion plenum 118 by blowing a small portion of their output out of a vent 68, thereby controlling the amounts of primary and secondary air supplied to the burner. A vane switch 148 in the vent senses air flow, in the absence of which the burner cannot be turned on.



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FIG. 1



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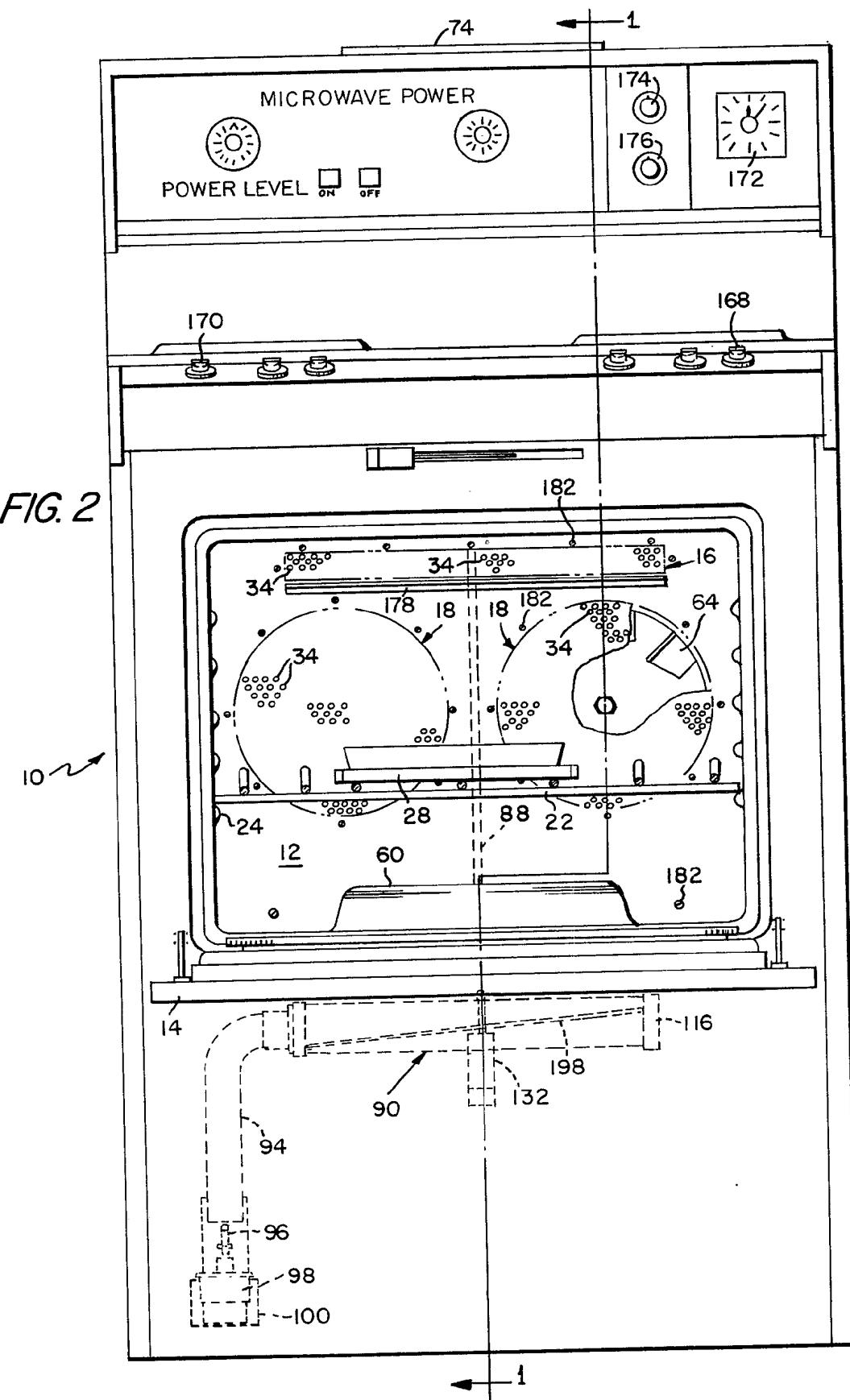


FIG. 3

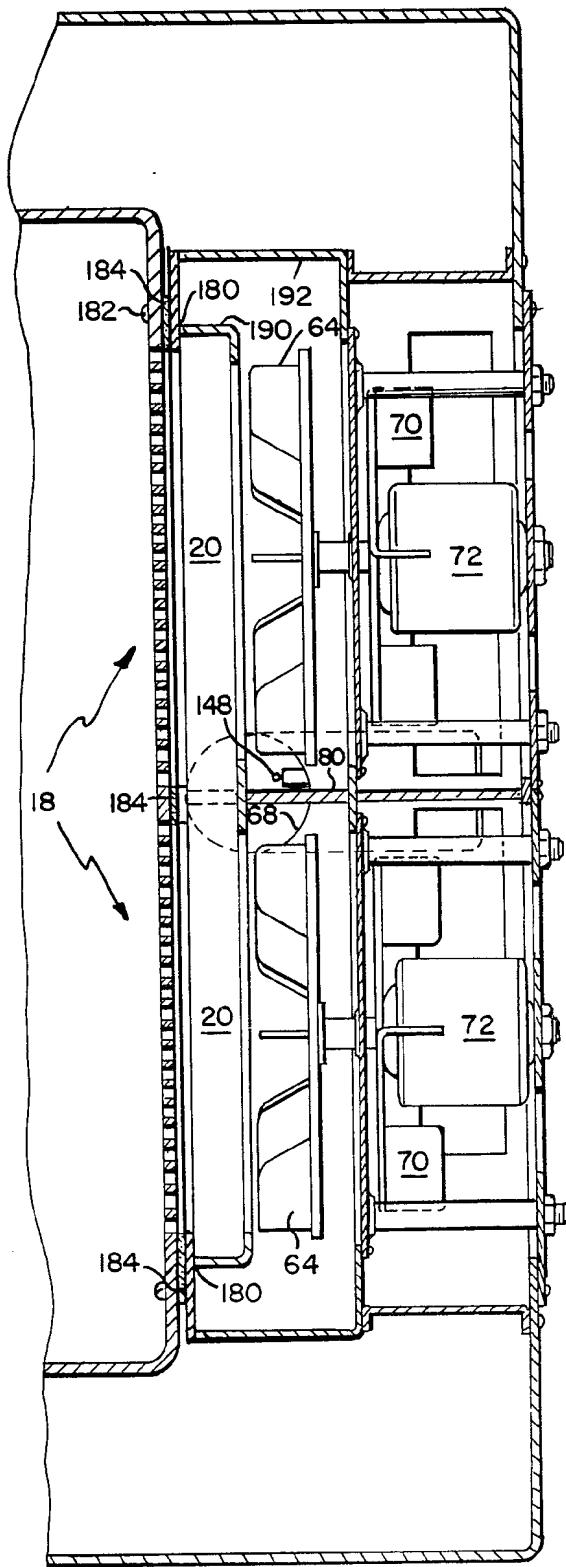
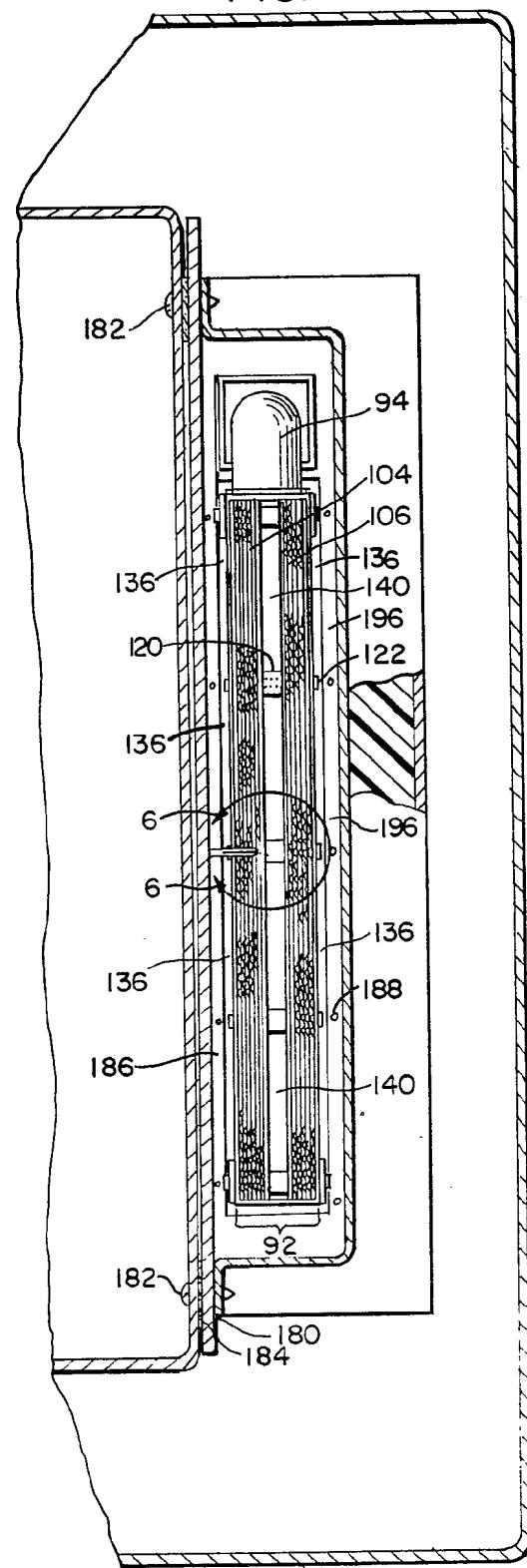
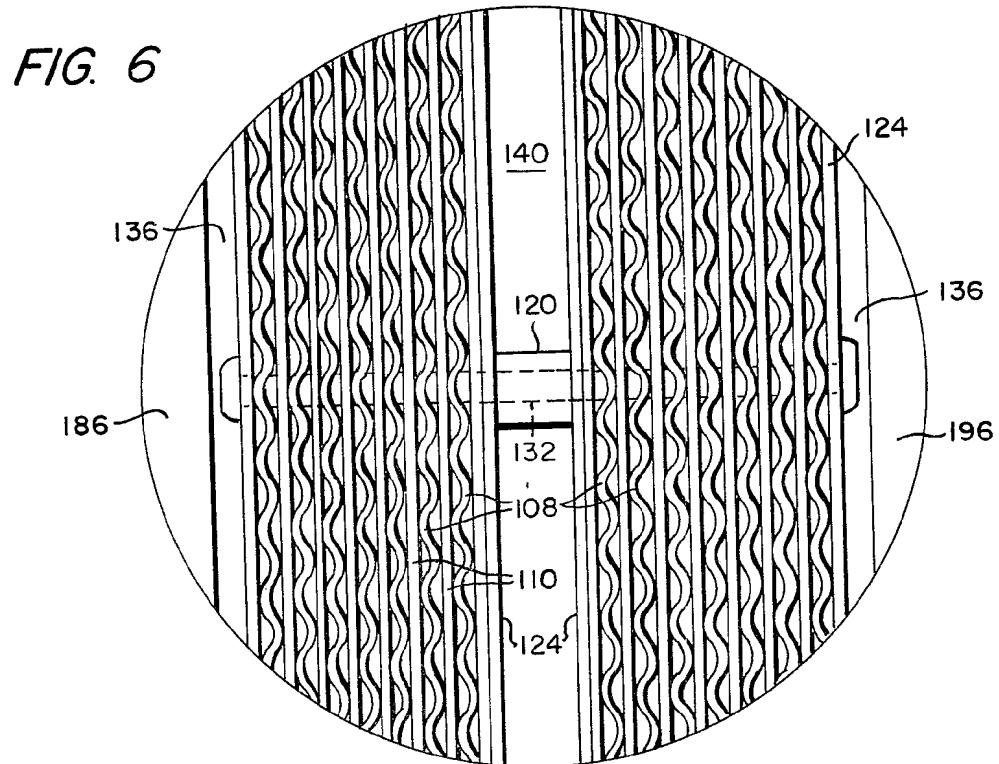
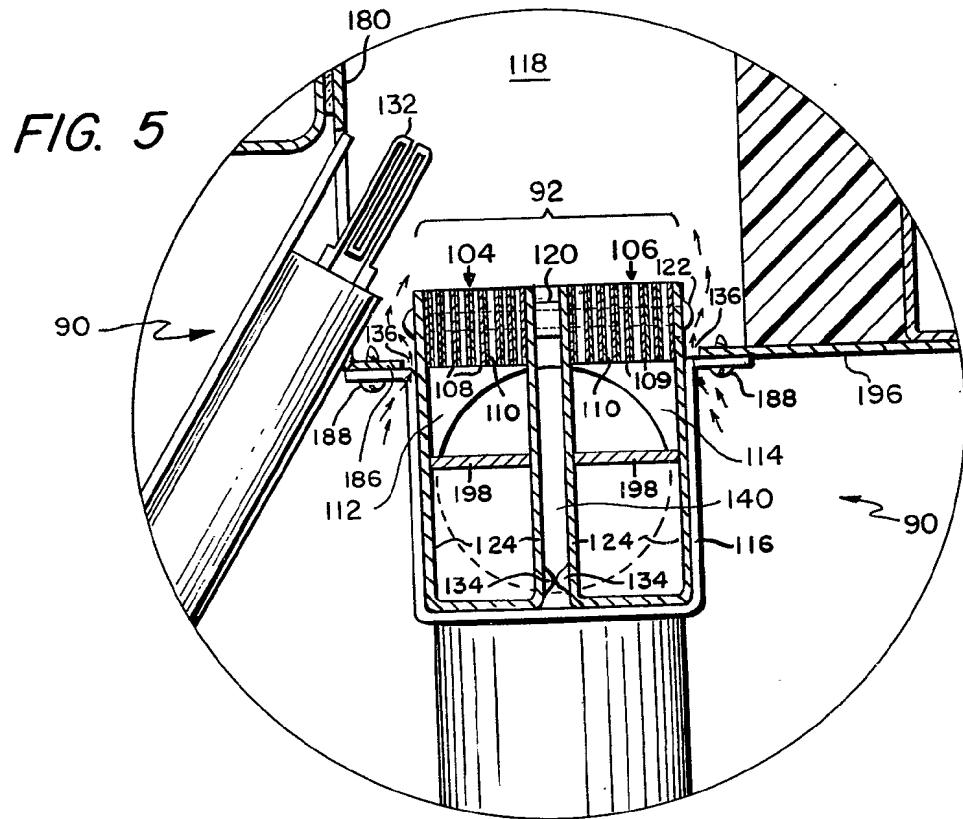


FIG. 4



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**SPECIFICATION****Gas burner convection oven**

5 Burner systems for domestic convection ovens have been provided with large combustion and/or mixing plenums to allow for large burner flame lengths. Also large amounts of excess air are used at normal baking temperatures since, when the oven is run at 10 its maximum temperatures such as for self-cleaning, the mass of air circulated is reduced. It has been usual to vent the oven directly and to use relatively high pressure blower systems to maintain a sufficient flow of excess air through the burner system at 15 self cleaning temperatures, so that undesirable generation of noxious fumes such as carbon monoxide does not occur.

In addition, it has been difficult to adequately monitor the actual flow of air into the burner system 20 so that if the blower fails the burner will reliably shut down.

According to the present invention there is provided, a convection oven comprising an oven enclosure, a gas burner outside the enclosure, and a 25 blower arrangement which circulates heated vapour through the enclosure, entraining the products of combustion of the burner, the burner being an elongated ribbon burner having a plurality of rows of orifices for gas mixed with primary air.

30 More specifically, the burner comprises a multi-section ribbon burner having sections spaced apart by a secondary air supply region. The height the burner flame above burner surface may be less than the total width of the burner system, for example, of 35 the order of 2.5cm high. The amount of excess air may be in the range of 65% to 150% of that required for complete combustion.

Preferably, the ribbon burner surface is positioned 40 at a level below the oven door and behind the rear oven wall containing the oven outlet through which vapour is drawn by the oven vapour circulation system. By using two counter-rotating blowers, positioned behind the rear oven wall, for the vapour circulation system, the power needed to drive the 45 blower may be a low value such as 50 watts.

In a preferred embodiment the gas burner is positioned adjacent to the input of the circulating blower system which is used for drawing vapour products out of the oven and recirculating the 50 products, mixed with the combustion products of the burner, back through the oven. The burner comprises a plurality of elongated ported sections for supplying a primary fuel-air mixture to a combustion plenum, separated by regions through which 55 secondary air is supplied to the combustion plenum. More specifically, the burner comprises a plurality of metal ribbons which are transversely corrugated along their length so that the corrugations act as the ports. Preferably, the ribbons have a width extending 60 from a supply plenum supplied with the primary fuel-air mixture, to the burner plenum. The ribbon width being sufficient to prevent flashback into the supply plenum even when relatively high primary fuel-air mixtures such as 50-80% are used. In addition, by having each of the ribbons separated from a 65

source of secondary air by a distance which is less than twice the transverse dimension of the port and by using in the order of 50% to 150% excess air, the height of the flame may be reduced to a dimension

70 which is substantially the same as or less than the transverse distance across the burner face between adjacent sources of secondary air.

Furthermore the burner may be continuously run at high power by using the negative pressure

75 created by the inlet of a blower, to draw the primary fuel-air mixture through the burner at a rate which lifts the burner flame front from the surfaces of the ports formed by the ribbons, so that heating of the burner port region is reduced, thereby reducing the 80 probability of flashback through the burner ports.

Furthermore by using a blower system which draws the combustion products out of the combustion plenum the input to the air-fuel primary mixture plenum of the burner may be fed from a gas

85 regulator through an orifice. Variations in blower speed or atmospheric pressure will then cause corresponding variations in the flow of gaseous fuel from the regulator so that greater uniformity of the fuel-air mixture may be maintained and hence the 90 excess air may be reduced from the normal 300% or so found in domestic gas appliances to less than 100% while still preserving a sufficient safety margin of excess air.

In addition the oven may have a control system in 95 which the circulating blower system actuates a switch in response to movement of the air or oven vapour, which switch controls the burner. Hence, if the blower system fails, for example, due to motor burn out or the impeller becoming loose on the 100 shaft, the burner is disabled, thereby providing a fail-safe condition of operation.

It has been found that by using a burner in which the excess air is substantially reduced, the output temperature of the burner may be raised to temperatures of the order of 980°C while still maintaining sufficient oxygen in the combustion products from the burner to readily pyrolyze cooking vapours or vapour deposits on the oven.

The invention will be described in more detail, by 110 way of example, with reference to the accompanying drawings, in which:-

*Figure 1* illustrates a partially broken away side elevation view of an oven embodying the invention taken along line 1-1 of *Figure 2*;

115 *Figure 2* illustrates a front view of the oven of *Figure 1*;

*Figure 3* illustrates a transverse sectional view of the oven of *Figure 1* taken along line 3-3 of *Figure 1*;

*Figure 4* illustrates a transverse sectional view of 120 the oven of *Figure 1* taken along line 4-4 of *Figure 1*;

*Figure 5* is an expanded view of the burner portion inside line 5-5 of *Figure 1*; and

*Figure 6* is an expanded view of the burner portion inside line 6-6 of *Figure 4*.

125 Referring now to Figures 1-6 there is shown a gas convection stove 10 comprising a metal oven cavity 12 of, for example, procelainized steel, which is closed by a door 14 during operation.

A rack 22 made, for example, of steel rods is 130 supported on bumps 24 formed in the side walls of

the enclosure 12 so that the position of the rack 22 may be changed in accordance with well-known oven practice.

The upper portion of the back wall of the cavity 12 has an elongated vapour inlet region 16. The middle portion of the back wall has a pair of vapour outlet regions 18. Vapour is drawn out of the enclosure 12 through the regions 18 into a plenum 20.

A microwave radiator 26 is positioned below the rack 22 and directs microwave energy up through the apertures in the rack 22, through a support plate 28, positioned in the middle of rack 22, and through a dish 30 containing a food body 32 such as a joint of meat. The dish 30 and the plate 28, are, preferably, substantially transparent to microwave energy so that the lower region of the food body 32 and the interior portions thereof may be heated effectively by microwave energy.

The radiator 26 may comprise, for example, a plenum 36 whose upper surface 38 contains a plurality of apertures 40 through which directive microwave energy patterns are radiated upwardly into the oven 12. A central conductor 42 of a coaxial line 44 supports plenum 36 by being attached to the centre of upper plate 38. The conductor 42 extends downwardly through an outer conductor 46 of the coaxial line 44 and through a waveguide 48 to a microwave choke and bearing assembly 50. An extension of the conductor 42 is rotated by a motor 52 positioned below the waveguide 48. Microwave energy from a magnetron 54 is fed through the waveguide 48 and the coaxial line 44 to the radiator 26. A blower 56 cools the magnetron 54 by blowing air past the fins 58. It should be noted that none of this air passes through the waveguide 48.

A cover 60 of microwave transparent material is supported over the radiator 26 on centering bumps 62 located on the bottom of the oven 12 so as to cover radiator 26 and thereby prevent food juices or other material from being dropped on radiator 26.

The door 14 is preferably sealed to the enclosure 12 by a high temperature vapour seal with a microwave choke structure positioned between the vapour seal and the interior of the enclosure 12. In this way microwave energy radiated into the oven 12 is largely prevented from being absorbed by the high temperature vapour seal. However, any microwave energy passing through the choke section is substantially absorbed by the high temperature vapour seal. When the door 14 is closed, a latch is mechanically moved to lock the door 14 shut and to permit energization of the magnetron 54. Further details and advantages of such a microwave oven feed and directive energy rotating structure are disclosed in greater detail in the specification of our copending patent application 79 37415 (Serial No. ). However, any desired microwave feed structure, radiator, and/or door seal could be used. It should be clearly understood that this invention may be used without the foregoing microwave energy system.

Preferably a slight negative pressure, such as 0.25 to 2.5 mm of water, is produced within the plenum 20 by a blower system comprising two counter-rotating centrifugal blowers 64 which draw vapour

out of the cavity 12, through the regions 18, into the plenum 20 and blow it out into plenums 66 surrounding the blowers 64 and supplying the region 16. The upper ends of the plenum 66 are connected

70 to an opening through which a small portion of the output of the blowers 64 passes through to an outlet vent 68 where the air is mixed with the air blown by a second set of blowers 70. The blowers 70 draw cool air in from the back of the stove 10 to cool motors 72 driving blowers 64 and 70, and to supply air to mix with the output of the duct 68 which then exits through a screened aperture 74 at the top of the stove 10 above the cooking surface.

As shown in Figures 2 and 3, each of the apertured regions 18 supplies vapours from the oven to the blowers 64. Each of the blowers 64 is driven, along with one of the blowers 70, by a common shaft of a separate motor 72 which is supported from a back wall 78 of the stove 10. The heat from blowers 64 is thus isolated from motors 72. A partition 80 between the two blowers 64 prevents tangential interaction of the vapour output of the blowers 64 which rotate in opposite directions to cause the air between the blowers to move upwardly, adjacent to the partition

90. It should be clearly understood that a single blower could be used in place of the dual blowers 64 and that the plenum 66 could have separate ducting systems to direct the vapour through a plurality of different regions 16 into the oven. However, it has been found that the dual counter rotating blower system can improve the uniformity of convection heating in the oven and reduce the blower power.

A burner system 90 is positioned at the rear of the stove 10 behind and below the enclosure 12. The burner system 90 comprises a ribbon burner 92 extending across a major portion of the width of the oven and fed at one end with a primary fuel-air mixture through a vertical tubular member 94. The open lower end of the member 94 is supplied with gas through a gas jet 96 which is controlled by a solenoid operated valve 98 and fed from a pressure regulator 100 through a gas line 102.

As shown in Figures 5 and 6, the ribbon burner 92 comprises two sections 104 and 106 each formed or 110 seven ribbons of sheet metal 108 approximately 13mm wide and 1mm thick extending the length of the burner, the members 108 being corrugated, for example, by a die. The corrugations run across the width of the members and are, for example, 5mm from peak to peak. Interspersed between the members 108 are flat members 110 of the same width and extending the length of the burner so that the spaces between the corrugations act as ports through which a primary fuel-air mixture, supplied by the pipe 94, can flow. The sections 104 and 106 are supplied from separate plenums 112 and 114 respectively which are both supplied at their ends from the pipe 94.

The plenums 112 and 114 are made in the shape of rectangular boxes 124 which are supported by 125 bracket members 116 extending from the bottom of a combustion plenum 118 communicating with the input to the blowers 64 through the plenum 20. The two sections 104 and 106 of the burner are separated by spacers 120 and are held together by rivets 122 extending through the spacers 120, all of the ribbon

members 108 and 110, and the walls of boxes 124. An air channel 140, positioned between the boxes 124 and through which secondary air is drawn into the combustion plenum 118, is formed by the

- 5 spacers 120 and by bumps 134 at the lower corners of the boxes 124. In addition, secondary burner air is drawn through spaces 136 around the outer edges of boxes 124. As a result, none of the burner ports 109, formed between the ribbons 108 and 110, is spaced
- 10 from a source of secondary air by more than three intervening ports.

It has been found that, by positioning the secondary air close to the burner ports 109, the flame height may be made less than the total width of the 15 burner section when sufficient fuel-air mixture is drawn through the ports 109 to cause the flame to lift off the ports by a distance of, for example, 2mm-4mm. Such flame lifting reduces the heating of the port ribbons 108 and 110 so that flashback ignition of 20 the primary fuel-air mixture in the plenums 112 and 114 is prevented even when a relatively high primary air-fuel ratio is used. By thus reducing the length of the flame, the combustion plenum 118 may be positioned across the lower rear corner of the oven 25 12 immediately below the outlet regions 18 of the oven and the combustion products drawn from the burner 92 will still be substantially dionized at the inputs to blowers 64.

In the preferred embodiment a safety control 30 circuit is provided in which an air flow sensor 148, comprising a vane actuated switch, is positioned in the vent 68. A manual selector control switch 168 energizes the blower motors 72 when one of the convection cooking modes is selected. The output of 35 the blowers 64 in the vent 68 closes the air sensor switch 148 to energize a conventional resistance heater ignitor 132 extending into plenum 118. After a time delay period of, for example, thirty seconds, the solenoid valve 98 is energized to allow gas to be 40 supplied to the jet 96. When the resultant fuel-air mixture reaches the combustion plenum 118 through the ports 109 in the burner 92, it is ignited by the ignitor 132 and the products of combustion are drawn into the blower 64 and blown into the 45 enclosure 12 through the inlet 16. The portion of the output of the blowers 64 which is blown out of the vent 68 creates a slight negative pressure in the combustion chamber 118 and in the enclosure 12 which controls the amounts of primary air drawn in 50 through the pipe 94 and secondary air drawn in around the edges of the burner sections 104 and 106. Since the tube 94 acts as an air restricting orifice for the primary fuel-air mixture, variations in blower speed and vapour temperature which vary the 55 primary and secondary air drawn into the plenum 118 also cause some variations in the flow of gaseous fuel through the regulator thereby reducing the possibility of an over-rich fuel-air mixture being burned which would cause noxious fumes to emanate 60 from the screen 74 at the top of the stove.

The burner 92 as shown herein can, for example, operate at a thermal output of 5.5-9kW. The thermal output is selected by selecting the sizes of the pipe 94, and the jet 96 as well as the setting of the fuel 65 pressure regulator 100. The secondary air is selected

by selecting the size of the space 140 between boxes 124 and the spaces 136 at the edges of the burner sections 104 and 106, through which secondary air is drawn into the combustion plenum 118.

- 70 The gas burner 92 may be controlled by turning a control selector knob 168 to a section marked convection heating and by setting a temperature control knob 170 to a convection vapour temperature. A timer such as, for example, a digital clock 172,
- 75 may also have on and off selector controls 174 and 176 for setting the time during which convection heat is supplied to the oven.

In operation, a temperature sensor bulb 178, mounted on a bracket in the enclosure 12 directly 80 beneath inlet region 16, senses the temperature of the vapour circulated in the enclosure 12 and when the vapour is below the temperature set by the control knob 170, the burner system 90 is energized.

Preferably the burner plenum 118 and the blower 85 input plenum 20 are fabricated as a unit separable from the enclosure walls of the cavity 12. As shown in greater detail in Figures 3-6, the plenums 20 and 118 consist of a flat wall member 180, containing holes corresponding to the vapour inlet and outlet 90 regions 16 and 18, which is attached to the back of the oven cavity 12, for example, by sheet metal screws 182 with a vapour tight seal being produced by means of high temperature gaskets 184 extending around the regions 16 and 18 and providing 95 thermal insulation between the combustion plenum 118 and the rear wall of cavity 12. As a result, the interior temperature of the combustion plenum 118, which may be 815-1,095°C is thermally isolated from the interior surface wall of the cavity which may be 100 porcelainized and capable of withstanding temperatures of around 540°C. The sheet 180 extends downwardly below the bottom of the cavity 12 and has a lip 186 bent at right angles thereto to form the edge of a plate spaced from the box 124 of the 105 section 112 by the secondary air passage 136. The brackets 116 are attached by screws 188 to the lip 186. Also attached to the sheet 180, for example, by welding, is the shroud member 190 which is positioned directly in front of the centrifugal blowers 64, 110 with holes concentric with and slightly smaller in diameter than the blowers 64.

The blowers 64 are positioned in the plenum 66 whose output is supplied to the vent 68. The outer wall member 192 of the plenum 66 is also welded 115 around its edges to the sheet 180 with the lower portion of the member 192 defining, together with the lower portion of the plate 180, the burner plenum 118. A recess in the lower all portion of member 192 holds a block of refractory material 194 to prevent 120 loss of heat outwardly from the burner plenum 118. The edge of the member 190 below the block 194 is bent at right angles to form a lip 196 at the same level as and extending towards the lip 186 so as to form a space 136 with the edge of the box 124 of the 125 burner plenum 114. Support bracket 142 is also attached to the lip 196 by a screw 188 so that the burner system 90 is rigidly attached to the lower end of the burner plenum 118 and the spaces 136, between the lips 186 and 196 and boxes 124, are 130 accurately controlled to provide a uniform slot for

the passage of secondary air into the combustion plenum 118. Similar lips are positioned at the ends of the burner plenums or the end spacings may be eliminated entirely. Preferably, the spacings between the lips 186 and 196 and the boxes 124 are made approximately one-half the spacing between the boxes 124 so that each of the ribbon burner sections 104 and 106, fed by a separate plenum, is also supplied with a uniform amount of secondary air along each edge thereof. As an example, if the total port area of the ribbon burner is approximately 32 cm<sup>2</sup>, being about 35 cm long and about 1.9cm wide with the port area being about half the burner surface area, then the spaces 136 may be about 0.5cm wide and the space 140 may be about 1.0 cm wide.

To improve the uniformity of the fuel feed to the sections 104 and 106, the plenums 112 and 114 have sloping bottoms 198 fixed at one end to the inner surfaces of the boxes and at the other end of the pipe 94. The sloping bottoms rise to points close to the ribbons 108 and 110 at the ends of boxes 124 which are farthest from pipe 94.

During normal baking operation, the burner blower system may operate with the primary air preferably being about 50 to 80% of that required for complete or stoichiometric combustion of the fuel, and with sufficient secondary air to provide 100% excess air in the combustion plenum 118. The average vapour temperature in the oven enclosure 12 is 150°C to 260°C. When the burner first starts, 150% excess air may be drawn into the plenum 118 since the blowers 64 will move a greater mass of the cooler air whereas when the burner is operated continuously for self-cleaning and the vapour temperature at the blowers 64 approaches 540°C less air is drawn through into the plenum 118, for example, only 65% excess air, and the combustion products become hotter. However, sufficient excess air is present to avoid production of noxious fumes such as carbon monoxide.

Among many possible modification the vapour may be circulated through apertures located in regions other than the back wall, any desired electrical and mechanical control system for the burner may be used, and other locations of the blowers and the burners may be used.

## CLAIMS

50

1. A convection oven comprising an oven enclosure, a gas burner outside the enclosure, and a blower arrangement which circulates heated vapour through the enclosure, entraining the products of combustion of the burner, the burner being an elongated ribbon burner having a plurality of rows of orifices for gas mixed with primary air.
2. An oven according to claim 1, wherein the burner comprises two sections running the length of the burner with a channel for the supply of secondary air between the two sections.
3. An oven according to claim 2, wherein the burner sections are flanked by passages for the supply of secondary air.
4. An oven according to claim 1, 2 or 3, wherein

no orifice is spaced by more than three intervening orifices from a margin of the burner wherat secondary air can flow into the flame.

5. An oven according to any of claims 1 to 4, wherein the orifices are formed by corrugated strips of metal sandwiched together to form the burner.
6. An oven according to claim 5, wherein the corrugated strips alternate with non-corrugated strips.
7. An oven according to any of claims 1 to 6, wherein the blower arrangement comprises two counter-rotating blowers.
8. An oven according to any of claims 1 to 7, wherein the blower arrangement comprises at least one pair of blowers driven by an electric motor, a first blower of the or each pair circulating vapour through the enclosure and the second blower of the or each pair drawing cooling air past the motor to a vent wherat is entrained a portion of the circulating vapour.
9. An oven according to claim 8, wherein the burner is positioned below the first blower of the or each pair.
10. An oven according to any of claims 1 to 9, wherein the blower arrangement establishes a negative pressure in the vicinity of the burner whereby substantial secondary air is drawn into the burner flame.
11. An oven according to claim 10, wherein the primary air is in the range of 50% to 80% of the air required for complete combustion and the primary and secondary air provide between 65% and 150% excess air over that required for complete combustion.
12. An oven according to claim 10 or 11, wherein the gas/primary air mixture is fed to the burner through a pipe providing flow restriction such that the blower arrangement increases the secondary air when the air is cooler and denser.
13. An oven according to any of claims 1 to 12, wherein the flame burns in operation lifted at least 2mm off the burner.
14. An oven according to any of claims 1 to 13, comprising a sensor responsive to air flow established when the blower arrangement is operating to provide an enabling signal for the burner.
15. An oven according to claim 14, comprising a temperature sensor responsive to vapour temperature in the oven enclosure to turn the burner on, subject to the presence of the enabling signal, when the temperature is below a preset value.
16. An oven according to claim 15, comprising a manually operated switch for turning on the blower arrangement and which also energises a circuit for turning the burner on, which circuit includes the temperature sensor.
17. A convection oven comprising an oven enclosure, a gas burner outside the enclosure, a blower arrangement which circulates heated vapour through the enclosure, entraining the products of combustion of the burner, and a sensor responsive to air flow established when the blower arrangement is operating to provide an enabling signal for the burner.
18. An oven according to claim 17, comprising a

temperature sensor responsive to vapour temperature in the oven enclosure to turn the burner on, subject to the presence of the enabling signal, when the temperature is below a preset value.

5 19. An oven according to claim 18, comprising a manually operated switch for turning on the blower arrangement and which also energises a circuit for tuning the burner on, which circuit includes the temperature sensor.

10 20. An oven according to any of claims 17 to 19, wherein the sensor responsive to air flow is a vane switch.

21. An oven according to any of claims 17 to 20, wherein the blower arrangement comprises at least 15 one pair of blowers driven by an electric motor, a first blower of the or each pair circulating vapour through the enclosure and the second blower of the or each pair drawing cooling air past the motor to a vent whereat is entrained a portion of the circulating 20 vapour.

22. An oven according to claim 21 insofar as dependent on claim 20, wherein the vane switch is in the vent.

23. A convection oven substantially as hereinbefore described with reference to and as illustrated in 25 the accompanying drawings.